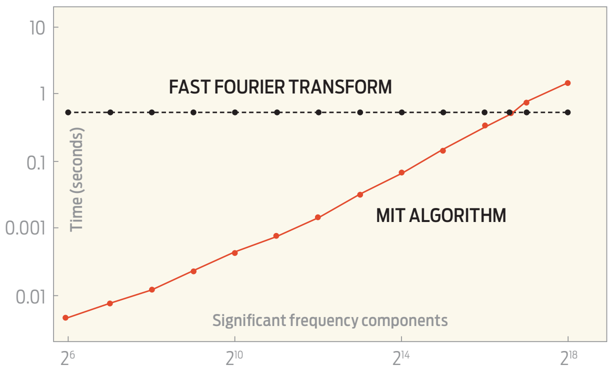
1.2 MEGAVOLTS Capacity of the highest-voltage circuit breaker yet made. Siemens plans to install it on a test transmission line in Bina, India.



SPEEDY: A new algorithm computes quickly when the signal it's working on has few important frequency components.

the traditional FFT so long as the number of frequency components present is a single-digit percentage of the number of samples you take of the signal. It works for any signal, but it works faster than the FFT only under those conditions, says Indyk.

Experts say the new algorithms coming from MIT represent considerable progress. "They've added some very smart ideas to the recipe," says Mark Iwen of Duke University, in Durham, N.C., who had earlier worked on the same problem with Anna Gilbert and Martin Strauss at the University of Michigan. The time it takes Iwen's best FFT algorithm to run increases in proportion to the fourth power of the logarithm of the number of samples, whereas the newest MIT algorithm has a run time that's proportional to just the first power of that number. "Removing those log factors is incredibly difficult," says Iwen, who also credits the MIT group for coming up with impressively fast computer implementations of their new algorithms.

Indyk points out that the library of code his group (and many engineers) uses to calculate the traditional FFT was released in the 1990s—three decades after Cooley and Tukey had worked out the basic computer procedures required. "We don't plan to spend 30 years developing a library," he says. "We plan to release our prototype code soon; researchers can just play with it and see what happens." Then, in something like six months, the MIT group should be able to provide a well-tested, portable library.

Why so long? "Developing decent code takes time," Indyk says. But there's another thing, he points out, that's bound to delay their release of a well-tested software library: "Every month or two we have a new idea."

—David Schneider

Virtual Power Plants, Real Power

Five kilowatts here, a hundred kilowatts there—with a smart grid, it all adds up

The Danish island of Bornholm, a quiet farming and fishing community of 42 000 in the Baltic Sea, will soon be home to one of the world's smartest smart grids. Through the four-year, €21 million (US $28 million) EcoGrid project, about 2000 households there will be connected to an island-spanning network that will enable homeowners to cut back their electricity usage at times of peak demand and sell that unused wattage back to the grid at market rates. Managing all of these thousands of discrete energy trades, as well as Bornholm's other power resources—including 36 megawatts of wind power, a 16-MW biomass plant, and a new fleet of electric cars—will be a central control system that behaves very much like a traditional power generator. Only this generator will be created entirely through software—a virtual power plant.

As its name implies, a virtual power plant doesn't exist in the concrete-and-turbine sense. Rather, it uses the smart-grid infrastructure to tie together small, disparate energy resources as if they were a single generator. Just about any energy source can be linked up. And energy that's *not* used can also contribute to a virtual power plant's capacity.

Here's how that will work: Households on Bornholm will be equipped with gateway controllers, which in response to spikes in electricity prices and the homeowners' preferences will automatically be able to turn off appliances or adjust the thermostat. The unused electricity can then be aggregated by the virtual power plant, along with other actual energy resources, and sold to customers who need power during peak times. Without the virtual power plant, the utility's only other option for meeting peak loads is to ramp up production, which can get very expensive, says Kim Behnke, head of R&D and smart grid development at the Danish utility Energinet.dk, which is overseeing the EcoGrid project.

The first virtual power plants came online about 10 years ago, mainly as research projects, says Thomas Werner, a product manager in Siemens's smart grid division who oversees the company's virtual power plant projects. But in the last several years, he says, energy market players have come to accept the virtual power plant as a commercially viable alternative to adding new capacity, as well as a way to handle the variability of renewables.

"Rather than having all these 5-kilowatt photovoltaic sources, you have a 100-MW virtual plant that for the utility is much more manageable," says Peter Asmus, a senior analyst at the market research firm Pike Research. "And it's temporary—you might stitch together those resources for just a half hour, to help meet peak demand." Pike Research estimates that the worldwide capacity of virtual power plants could grow from 45 gigawatts last year to as much as 105 GW by 2017, with revenues of about $6.5 billion.

A virtual power plant also lets smaller energy producers take part in energy markets from which they might otherwise be excluded. One plant set up by Siemens aggregates 1450 MW of capacity from small generators installed in hospitals, industrial facilities, and commercial buildings throughout Germany. Ordinarily, each of these units would be used only during emergencies and only to power its particular site. Hooked up via the virtual power plant, they can now be fired up whenever market rates or grid conditions make it worthwhile.

A remaining challenge, Werner says, is that there is no standard interface between the central control system that manages and optimizes the virtual power plant and the distributed energy resources out in the field, many of which may not have been designed to communicate with an IT network.

The virtual power plant concept is an obvious culmination of the decadelong push to deploy smart meters, sensors, and other infrastructure, says Amit Narayan, director of smart grid research in modeling and simulation at Stanford University. "If you think about the evolution of the Internet, it's the same thing," he says. "Somebody had to lay the wires and build the infrastructure, but once that's in place, a lot more can be done in terms of creating new applications."

And in much the same way that Google, Facebook, and Amazon troll through user data to discern subtle patterns in people's tastes and then try to influence their buying habits, Narayan says, virtual power plants give grid operators the means to study their customers' electricity usage and then try to get them to modify their behavior in a way that increases the capacity of the virtual power plant.

Indeed, changing people's habits should be one of the chief outcomes of the Bornholm project,

BRIGHT GREEN: Denmark's Bornholm Island will soon have the world's most advanced virtual power plant, as part of a €21 million smart grid project.
PHOTO: JACEK KADAJ/GETTY IMAGES

says Behnke, because when consumers use less electricity, they'll not only reduce their electricity bill, they'll also get a bonus based on the market price for the electricity at that time. "We hope to show that even these small customers can help balance the grid, based on actual need within the hour," he adds. His company estimates that the virtual power plant should help reduce peak loads on the island by at least 20 percent.

While Denmark already has a number of virtual power plants, they're all designed to allow large electricity customers to trade energy in the day-ahead market, Behnke says. "That's what we call Smart Grid, version 1. Now we are going for Smart Grid, version 2." —Jean Kumagai